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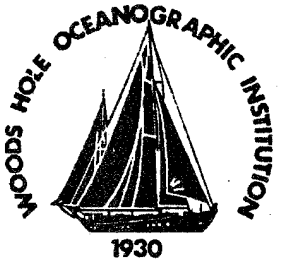

Advanced Engineering Laboratory Project Summaries 1993

by

Daniel E. Frye, Editor

December 1994

Technical Report

Funding was provided by the Woods Hole Oceanographic Institution.

WHOI-94-24

Advanced Engineering Laboratory Project Summaries 1993

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Daniel E. Frye, Editor

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

December 1994

Technical Report

Funding was provided by the Woods Hole Oceanographic Institution.

Approved for Distribution:

George V. Frisk

George V. Frisk, Chair
Department of Applied Ocean Physics and Engineering

ABSTRACT

The Advanced Engineering Laboratory of the Woods Hole Oceanographic Institution is a development laboratory within the Applied Ocean Physics and Engineering Department. Its function is the development of oceanographic instrumentation to test developing theories in oceanography and to enhance current research projects in other disciplines within the community. This report summarizes recent and ongoing projects performed by members of this laboratory.

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ADAPTIVE EQUALIZATION TECHNIQUES FOR INTERFERENCE SUPPRESSION IN SHALLOW WATER ACOUSTIC TELEMETRY CHANNELS

Zoran Zvonar, David Brady and Josko Catipovic

ABSTRACT

Despite the severe propagation conditions in shallow water acoustic telemetry channels, coherent high-speed data transmission may be established using adaptive receivers based on a decision feedback equalizer (DFE) structure. The performance of a DFE in shallow water acoustic networks is affected by substantial co-channel interference from acoustic modems, in addition to extended, time-varying ISI and large Doppler fluctuations.

In this paper we address the interference suppression ability of a DFE by evaluating a channel-specific structure for reliable interference suppression and dynamic channel tracking. The DFE performance is compared to an adaptive multiuser receiver which jointly performs adaptive equalization and multiple-access interference cancellation.

Published in Proceedings of the 27th Annual Asilomar Conference on Signals, Systems and Computers, Pacific Grove, California, November 1993.

Funding provided by: Advanced Research Projects Agency under Contract MDA 972-91-J-1004.

ADAPTIVE MULTICHANNEL COMBINING AND EQUALIZATION FOR UNDERWATER ACOUSTIC COMMUNICATIONS

M. Stojanovic, J. Catipovic, and J. G. Proakis

ABSTRACT

A theoretically optimal multichannel receiver for intersymbol interference communication channels is derived, and its suboptimal versions with linear and decision feedback equalizer are presented. A practical receiver based on any of these structures encounters difficulties in the underwater acoustic channels in which the extended time varying multipath is accompanied by phase instabilities. A receiver which overcomes these problems by jointly performing adaptive mean squared error diversity combining, multichannel carrier phase synchronization and decision feedback equalization is proposed. Its performance is demonstrated on experimental telemetry data from deep and shallow water long range acoustic channels. Presented results indicate superior quality of coherent PSK and QAM reception obtained through joint equalization of very few channels.

Funding provided by Advanced Research Projects Agency under contract MDA972-91-J-1004.

Published in Journal of Acoustical Society of America, 94(3), pp 1621-1631, 1993.

ADAPTIVE MULTIUSER RECEIVER FOR SHALLOW WATER ACOUSTIC TELEMETRY CHANNELS

Zoran Zvonar, David Brady and Josko Catipovic

Recent advances in coherent underwater communications technology are the backbone of an Acoustic Local Area Network (ALAN) which is designed for a real-time underwater telemetry with multiple sensors or unmanned underwater vehicles. In shallow water areas ALAN is planned to cover 100-1000 km^2 with nodes designed to communicate at 10 Kbit/sec at ranges 3-4 nm. The communication protocol is optimized for the shallow water acoustic environment, minimizing retransmission from finite-energy transceivers and taking into account time-variant link reliability and long propagation time between the nodes.

One of the key elements of this protocol is a multiuser receiver capable of simultaneously demodulating signals coming from several asynchronous co-channel modems. Online spread-spectrum systems and narrowband transmission are used. The propagation conditions in shallow water are severe due to the highly dynamic multipath structures and the adaptive multiuser receiver performs joint multiple-access cancellation, equalization, phase tracking and bit timing recovery. It consists of a fractionally spaced feedforward section, coupled digital phase-locked loops and feedback sections which utilize previous decisions both from the desired and the interfering user. The adaptive algorithm is the combination of the recursive least squares algorithm for filter tap weights and a second order phase update for the carrier recovery loop.

Extensive testing has been carried out to confirm successful operation of the proposed receiver in a variety of propagation conditions using experimental data provided by the Woods Hole Oceanographic Institution. Our results indicate significant performance gain over the conventional receiver at the expense of a modest increase in complexity.

Presented at 125th Meeting of the Acoustical Society of America, Ottawa, Canada, May 1993.

Funding was provided by Advanced Research Projects Agency under Contract MDA-972-91-J-1004.

ADAPTIVE RECEIVERS FOR UNDERWATER ACOUSTIC COMMUNICATIONS: THEIR RELATION TO BEAMFORMING AND DIVERSITY COMBINING

M. Stojanovic, J. Catipovic and John G. Proakis

ABSTRACT

A major difficulty encountered in underwater acoustic (UWA) channels is the extended and dynamic multipath propagation. At the same time, the relative simplicity of building a hydrophone array, and the relatively low data rates used, offer advantages of both multichannel combining and powerful equalization methods for UWA communications. In order to select a suitable combining method, we consider an optimal multichannel receiver for a general ISI communication channel. When there exists a certain spatial distribution of the signals across the array, the optimal combiner can be identified as a "beamformer" and a bank of filters matched to the individual path responses. This beamformer differs from a conventional one in that it does not null out the multiple signal reflections, but makes use of them.

The optimal receiver structure gives rise to two classes of adaptive implementations. The first class makes no assumptions about the spatial signal distribution, and corresponds to pure diversity combining. The second class explicitly uses knowledge of the angles of signal arrivals. For the receiver of the second class, we present an algorithm for joint adaptive equalization and tracking of the angles of arrival. While the receiver of the first class has an advantage of not being sensitive to any propagation model mismatch, its computational complexity may become very high when a large array is used together with long equalizers. To reduce the receiver complexity, but make no explicit assumptions about the relationship between the array signals, we combine the two approaches considered. The resulting beamformer and reduced-complexity equalizer are optimized jointly, providing the same MSE performance as that of the full-complexity multichannel equalizer.

To compare the approaches considered, we derive the condition for equality between the full-complexity multichannel combiner and an arbitrary fixed beamformer followed by a smaller adaptive combiner. We use this condition to check the equivalence for several interesting beamforming strategies, whose performance, together with that of the fully adaptive combining methods, is demonstrated in simulation.

Published in Proceedings COMCON4, Rhodes, Greece, June 1993.

Funding provided by Advanced Research Projects Agency under Contract MDA972-91-J-1004.

THE ANNUAL VARIATION OF WATER MASSES IN THE GULF OF MAINE: 1986-87

J. D. Irish and W. S. Brown

ABSTRACT

Circulation in the Gulf of Maine on monthly to seasonal time scales is primarily controlled by its changing thermohaline structure. Identifiable water masses, which characterize this structure, were monitored from August 1986 through September 1987 by a combination of moored array and a series of shipboard hydrographic surveys of temperature and conductivity. The inflow of Slope Water kept the Georges Basin waters stratified throughout the year. Surface cooling during winter led to deep mixing in Wilkinson Basin, where the water column became nearly isothermal and isohaline to depths greater than 150 meters. Inflows of fresher Scotian Shelf Water in early winter and early spring runoff accumulated in Jordan Basin during the first part of 1987. Wintertime processes create the water mass structure in the gulf each year. The seasonal variation in the structure and volumes of 1987 water masses - defined in terms of April water properties - were determined. The volume of the principal early spring water mass - Maine Intermediate Water - decreased through the summer as it (a) flowed out of the gulf and (b) mixed with Maine Surface and Slope Water to form Maine Bottom Water and a Mixture Water mass. Slope Water inflow increased and then decreased during the summer. By mid-summer, Mixture Water had replaced Intermediate Water at mid-depth throughout much of the eastern gulf. By September, significant amounts of 1987 Intermediate Water remained in Wilkinson Basin.

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Funding provided by National Science Foundation under contract OCE-8818060 and NOAA Sea Grant.

AUTOMATED INSTRUMENTATION FOR TIME-SERIES MEASUREMENT OF PRIMARY PRODUCTION AND NUTRIENT STATUS IN PRODUCTION PLATFORM-ACCESSIBLE ENVIRONMENTS

Craig D. Taylor, Brian L. Howes, and Kenneth W. Doherty

ABSTRACT

A major limitation to the assessment of the temporal and spatial variability of key ecological parameters is the ability to perform complex biological and chemical procedures autonomously in situ. We present new instrumentation for the automated in situ measurement of photosynthesis and other microbial processes and for assessment of micro-nutrient pools in coastal and oceanic environments. High resolution time-series studies of photosynthesis using a submersible incubation device (SID) indicates that the standard sampling interval commonly employed in coastal and oceanic studies can lead to significant errors in the determination of the temporal patterns of photosynthesis and quantification of integrated measures of production expressed on a seasonal or annual basis. Clearly, methodologies that allow for the higher frequency measurements required to quantify this key ecological parameter adequately are needed. In addition, SID technology was found to avoid both potential handling artifacts of standard techniques. Since photosynthesis rates must often be interpreted in context with the nutrient regime of the environment, an autonomous in situ continuous flow chemical analyzer (in situ-CFA) has been developed for parallel deployment with the SID. Both SID and in situ-CFA instruments, when incorporated into regional arrays of automated moorings that are supported by offshore platform research programs, should greatly facilitate the gathering of data essential to our understanding of the meso-scale processes controlling biological systems in the coastal and oceanic environment.

Published in MTS Journal, Vol. 27, No. 2, p. 32-44, 1993

Funding provided by NOAA/SEAGRANT under Contract Numbers NA86-AA-D-SG090-R/P-95-PD and R/P-34 and NA90-AA-D-SG480 R/P-38; The Department of Energy under Contract DE-FG02-92ER-61426; and National Science Foundation under Contracts DPP-91-18363 (amendment #1) and OCE-90-00112.

AUTONOMOUS OCEANOGRAPHIC SAMPLING NETWORKS

**Thomas B. Curtin, James G. Bellingham,
Josko A. Catipovic and Doug Webb**

ABSTRACT

With current trends, advances in a significant class of ocean science problems will be increasingly platform limited. An approach to this problem is the Autonomous Oceanographic Sampling Network (AOSN). Each network node consists of a base buoy and a selectable number of small Autonomous Underwater Vehicles (AUVs). Network configuration is driven by the science or application addressed. A relevant oceanic volume is defined, based on modeling or data voids. Acceptable gradient error bounds are estimated. Appropriate sensors, nodal distribution and initial sampling strategy are then determined with allowance for adaptive adjustment. Design is based on many low-cost, lightweight vehicles with simple, reliable navigational skills. Implementation capitalizes on state-of-the-art technology and proceeds systematically in a series of well-defined, manageable steps toward progressively more complex scientific questions. Use of an AOSN entails a fundamentally different approach to ocean sampling in which hypothesis testing using interactive experiment design and execution plays a major role.

Funding for various components of this work has been provided by ONR Grant N00014-93-1-0988, ARPA Contract MDA 972-91-J-1004, NSF Contract OCE-92-01191, and MIT Sea-Grant College Program under Contract NA90AA-D-SG424.

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A COMPARISON OF RECEIVER DESIGN AND PERFORMANCE FOR THREE TYPES OF UNDERWATER ACOUSTIC TELEMETRY CHANNELS

Milica Stojanovic, Josko Catipovic and John G. Proakis

ABSTRACT

In this presentation the issues concerning the impact of channel structure and dynamics on the design and performance of a decision feedback equalizer (DFE) type of receiver for coherent underwater acoustic (UWA) telemetry is discussed. The receiver, developed as a part of the feasibility analysis of coherent communications over UWA telemetry channels, consists of a fractionally spaced DFE and a passband digital phase-locked loop. The adaptive algorithm for updating the receiver parameters is a combination of the recursive least-squares algorithm for the equalizer tap weights and a second-order phase update for carrier recovery. The receiver jointly performs channel equalization, symbol timing, and carrier phase synchronization, using the minimum mean-squared error criterion.

Besides processing the single-channel signal, the receiver structure and the algorithm are extended to the multichannel case in which coherent diversity combining of different spatially distributed signals is performed. This receiver algorithm was applied to the experimental data originating from the three fundamentally different ocean environments, namely long range-deep water, long range-shallow water, and short range-shallow water channels.

The experiments, conducted by the Woods Hole Oceanographic Institution, were performed in the deep waters off the coast of northern California (long range), on the New England Continental Shelf (long range-shallow water), and in Buzzards Bay (short range).

Propagation in deep water, which occurs in convergence zones, results in long, but fairly stable multipath structures. Channel impulse responses, which are typically nonminimum phase, span several tens of milliseconds, requiring at least 40 taps in the feedforward section of the equalizer at data rates of 300 symbols per second. In the cases of strictly maximum phase channel responses, some reduction in complexity can be achieved by time-reversed equalization. The multipath structure of the shallow water channel is much less stable than that of the deep water channel, due to the presence of large amounts of bottom and surface reverberation. The impulse responses are again nonminimum phase, typically characterized by extended multipath propagation following the main arrival. Equalizer lengths of as many as 100 feedforward and 80 feedback taps were needed in some cases of transmission at 1000 symbols per second.

In all of the mentioned UWA channels, successful operation of the receiver algorithm for joint synchronization and equalization has been achieved. Experimental results assert the feasibility of coherently combining multiple arrivals at the expense of high computational complexity of the receiver. With the transmitted power constraint, performance limitations encountered at very high data rates lie both in the increased noise levels, as well as in the increased computational complexity of extremely long equalizer structures needed to overcome the intersymbol interference problem caused by multipath propagation. Future work should be directed towards finding the ways to reduce the equalizer complexity, which will result in improved performance by virtue of reducing noise enhancement in the equalizer.

Funding was provided by Advanced Research Projects Agency under contract MDA972-91-J-1004.

Published in Proceedings 124th Acoustic Society of America, Vol 92, No. 4., Pt 2, 1992.

DESIGN AND TESTING OF THE AUTONOMOUS BENTHIC EXPLORER

Albert M. Bradley and Dana R. Yoerger

ABSTRACT

The Autonomous Benthic Explorer (ABE) is an autonomous underwater vehicle designed to perform long-term repeated surveys in the deep ocean. We designed ABE in response to the needs of biologists and geologists who study hydrothermal vents. These deep water hot springs are very dynamic, and a comprehensive understanding of their long-term variability requires time-series observations that cannot be achieved solely from the limited time windows offered by manned submersibles and remotely operated vehicles. Likewise, the mobility of a vehicle can significantly enhance data from moored and bottom-mounted instruments.

These needs dictated the basic design of ABE. ABE will be able to descend to a prepared site on the bottom, dock to a mooring, and place itself in a very low power "sleep" state. Then, at preplanned intervals, ABE will undock, perform a grid survey, then redock to the mooring. ABE's principal data will be monochrome and color video stills of the bottom and basic CTD measurements.

While ABE was designed with a particular type of mission in mind, we have designed the subsystems to be applicable to a wide range of AUV applications. In this paper, we give an overview of several of the most important ABE subsystems, illustrated by our initial dockside and deep-water test data.

Presented at Autonomous Underwater Vehicles '93 Conference.

Funding by National Science Foundation under Contracts OCE-90-20227 and OCE-92-16775.

DEVELOPMENT OF UNDERWATER ACOUSTIC MODEMS AND NETWORKS

Josko Catipovic, David Brady and Steven Etchemendy

ABSTRACT

Recent developments in underwater acoustic communication enable digital communication with underwater sensors, vehicles and other instruments, offering novel ocean observational capabilities which may change future oceanographic operations. This article summarizes the current state of the art in underwater acoustic communication and telemetry equipment. Several currently deployed observational systems illustrating the potential of the new technology are presented.

Funding provided by National Science Foundation under contract OCE92-01191

Submitted to "Oceanography", August 1993.

DSP-BASED ACOUSTIC TELEMETRY MODEMS

Steve Merriam and Dave Porta

ABSTRACT

Underwater acoustic digital communications, historically,has been characterized by unreliability and low data rates, due primarily to a lack of capable electronics in affordable packages. The underwater acoustic channel is typically characterized by high reverberation, strong fading, and sometimes high noise. Shallow water horizontal channels tend to be the most difficult in which to perform acoustic communications, whereas vertical links in the deep ocean require much less processing. Environmental conditions force tradeoffs between data rates, error rates, and receiver processing complexity.

The recent proliferation of high performance, low power DSP chips have allowed WHOI and Datasonics engineers to develop highly capable acoustic telemetry modems that offer robust performance at high data rates yet at reasonable cost to potential users. The high speed modems employ multiple frequency shift keying (MFSK) modulation, where simultaneous acoustic tones are used to transmit data bits in parallel.

MFSK modulation is a good choice for underwater communications since the tone duration can be lengthened to combat multipath effects and still achieve high data rates. Operation over both deep water vertical and shallow water horizontal paths have resulted in reliable data transmission at 1,200 b/s with error rates of 10^{-5} to 10^{-6}.

Datasonics' ATM-845 acoustic link is used for the subsea end of a link characterized by low-speed command and control signaling down and high-speed data recovery up. Two units operate at the sea surface - the ATM-851 for shipboard use and the ATM-850 module for use in a surface-moored buoy where it is interfaced with RF telemetry (usually a satellite link). The ATM-850 can also be packaged with battery and transducer in a pressure housing for applications such as UUV communication, which may require high speed data telemetry in both directions.

Funding provided by National Science Foundation under contract OCE-92-01191.

Published in Sea Technology, May 1993.

GLOBAL ACOUSTIC MAPPING OF OCEAN TEMPERATURES (GAMOT)

J. L. Spiesberger, D. E. Frye, J. O'Brien, H. Hurlburt, J. W. McCaffrey, M. Johnson, and J. Kenny

ABSTRACT

The Kaneohe source experiment in the 1980's demonstrated the feasibility of using sound to monitor global warming trends in the ocean. This experiment used a source cabled to shore and the Navy's SOSUS stations for receivers. The GAMOT group is developing new instruments to obtain similar data in near-real time but at about one-eighth the cost of instruments cabled to shore. This approach has the potential for obtaining global ocean measurements of temperature at 500 km resolution less expensively than that routinely expended for measuring atmospheric temperatures. GAMOT is using sate-of-the-art models of the ocean to interpret temperature changes.

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Published in IEEE Proceedings Oceans '93, Victoria, British Colombia, October 1993.

INDUCTIVE TELEMETRY ON A DEEP OCEAN SURFACE MOORING

Daniel Frye, Alessandro Bocconcelli, Stephen Liberatore and Edward Hobart

A long term engineering test of ocean data telemetry using inductive coupling is being performed offshore Bermuda as part of the ONR-sponsored Atlantic Long Term Oceanographic Mooring (ALTOMOOR) program. Inductive modems are general purpose telemetry devices which can be used with standard, plastic-jacketed steel mooring lines to transmit data between instruments in the water column and a receiver in the surface buoy.

The advantage of inductive coupling over electrically connected instrumentation is that expensive and unreliable electromechanical cables and terminations are not needed to accomplish real time data telemetry. The modems send and receive data via toroids clamped around the wire which act as single turn transformers. Data telemetered up the wire are sent at a rate of 1200 b/s; commands are sent down the wire at 300 b/s.

Funding was provided by the Office of Naval Research under Contract N00014-90-J-1719.

Published: Proceedings, MTS '93, November 1993.

INSTRUMENT TO MEASURE ELECTROMAGNETIC FIELDS ON CONTINENTAL SHELVES

R.A. Petitt, Jr., J. H. Filloux, H.H. Moeller, and A.D. Chave

ABSTRACT

We have constructed a set of instruments designed explicitly for shallow water (up to 1000m) electromagnetic measurements. These units record (with sixteen bit accuracy on EPROM memory cards) the vector horizontal electric field, the vector variations of the magnetic field, pressure, temperature and two components of tilt at a nominal sample rate of 2 Hz for a month. This could be extended to 10 Hz for short experiments as the sensors are easily capable of operation to this point.

Funding provided by National Science Foundation under grant EAR-9206820.

Published in Proceedings Oceans '93, Vol. I, pp 164-168.

JASONTALK: A STANDARD ROV VEHICLE CONTROL SYSTEM

**David A. Mindell, Dana R. Yoerger, Lee E. Freitag,
Louis L. Whitcomb, Robert L. Eastwood**

ABSTRACT

A new control system developed for the Woods Hole Oceanographic Institution (WHOI) JASON vehicle is described. The system was developed as a complete upgrade to both the surface command and control unit as well as the computers aboard the vehicle. Several key features of the JasonTalk system are: heterogenous design, process-based control with message passing communication and a segmented architecture for fault tolerance and easy reconfiguration.

Funding provided by Office of Naval Research under contract N00014-90-J-1912.

Published in Proceedings, Oceans '93, Victoria, British Colombia, October 1993.

MODULAR ALAN NODE (MAN) ELECTRONICS

Lee Freitag, Dave Herold and Steve Merriam

This report describes a preliminary design for an underwater acoustic signal processing system. The design is based on requirements for greater than 50 MFLOPS signal processing capability and for in-water operation of approximately 90 days using an external battery pack. The design is thus performance driven, and while efforts have been made to keep power consumption low, this is not meant to be an ultra-low power design. This is primarily dictated by the power required by the processors, 4 to 5 watts per DSP module with memory.

Because of the limitations of a fixed architecture, single-processor system, the electrical and mechanical specifications for the new system were developed to allow for easy upgrading and addition of new processors and sub-systems as applications require and technology develops. Thus, the design presented here is a modular, open architecture based on a simple I/O bus for controlling devices like analog to digital converters and Texas Instruments C40 DSP processors.

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(Not published, internal report)

MULTIUSER DETECTION AND DIVERSITY COMBINING FOR WIRELESS CDMA SYSTEMS

Zoran Zvonar

ABSTRACT

Multipath fading presents a major limitation for the performance of wireless CDMA systems. Multipath propagation alone enhances multiple-access interference and fading on propagation paths induces the near-far problem. Multiuser detection has the capability of eliminating the near-far problem and providing a capacity increase in CDMA systems, while diversity reception combats the fading effects of the channel.

We investigate multiuser receivers which combine explicit antenna diversity, RAKE multipath diversity and multipath decorrelating detection. Both coherent reception with maximal-ratio combining and differentially coherent reception with equal-gain combining are analyzed. The results demonstrate significant performance improvement over the conventional RAKE techniques. In the case of limited receiver complexity, when the number of correlators is smaller than the number of resolvable paths at the RAKE front-end, antenna diversity is shown to be effective in reducing residual multiple-access interference.

Published in IEEE Transactions on Communication 4th WINLAB Workshop on Third Generation Wireless Networks, Rutgers University, NJ, October 19-20, 1993.

Funding provided by Advanced Research Projects Agency under Contract MDA972-91-J-1004.

REDUCED-COMPLEXITY SIMULTANEOUS BEAMFORMING AND EQUALIZATION FOR UNDERWATER ACOUSTIC COMMUNICATIONS

Milica Stojanovic, Josko A. Catipovic and John G. Proakis

ABSTRACT

Multichannel spatial signal processing of high-speed underwater acoustic communication signals is associated with computationally intensive receiver algorithms. Besides requirements in computational time, large adaptive filters operating under computationally efficient algorithms imply increased sensitivity to numerical errors and large noise enhancement, which limit their performance at high signaling rates. To overcome these difficulties, a receiver is proposed which consists of a multi-input, multi-output combiner in which many input channels are coherently combined into a smaller number, suitable for subsequent multichannel decision-feedback equalization. Receiver operations are optimized jointly to ensure minimum mean-squared error detector performance. Experimental results obtained on a long-range shallow water channel with data rates up to 2000 bits per second demonstrate the receiver capability to fully exploit the spatial diversity of underwater multipath while keeping the receiver complexity at a minimum, thus allowing both fast convergence and little noise enhancement.

Published in Proceedings, Oceans '93, Victoria, British Colombia, October 1993, pp III 426-431.

Funding provided by Advanced Research Projects Agency under Contract MDA-972-91-J-1004.

SEQUENTIAL DECODING WITH SELECTIVE REPEAT FEC/ARQ CODE COMBINING A ROBUST METHOD FOR UNDERWATER ACOUSTIC COMMUNICATION WITH UNDERWATER VEHICLES

Josko Catipovic

ABSTRACT

Autonomous underwater vehicles (AUVs) typically operate in difficult communication environments. This paper presents a protocol for robust underwater acoustic communication with AUVs operating in shallow water environments. The acoustic channel is characterized by extended and highly dynamic multipath and severe jamming, largely from unintentional causes, such as nearby ships. The relatively slow speed of sound causes long propagation delays, while bandwidth restrictions typically limit system throughput to 10 kbits/sec over a 5 km path. The combination of the slow data rate and high allowable system complexity allow use of complex decoder algorithms, and the principal system constraint is the need to maintain data throughput with a minimum of transmissions. These requirements are ideally met with a code combining sequential decoder.

This work presents a code combining sequential decoding protocol which minimizes transmitter power at the expense of long decoding delays and significant computational requirements. ARQ retransmit packet length is optimized with respect to decoder error performance, transmitter power, and overall message decoding delay. The resultant operational point balances received SNR with mean message decoding delay. The developed algorithm is implemented in an underwater local area network for communication between underwater vehicles, sensor platforms, and surface assets.

Published in Proceedings, ConCom4 Conference, Rhodes, Greece, June 1993.

Funding provided by Advanced Research Projects Agency under contract MDA-972-91-J-1004.

SHALLOW WATER ACOUSTIC CHANNEL MONITORING WITH SELECTIVE MODE EXCITATION

James C. Preisig and Josko Catipovic

ABSTRACT

The shallow water environment is characterized by multiple processes which cover a wide range of temporal and spatial scales and which have a significant effect on the propagation of acoustic signals. The coupling between the modes of acoustic signals is potentially an effective means of monitoring these processes. Traditionally, a single source is used to excite the acoustic medium. A receiver array is used to sort out the modes of the propagating signal and the coupling between particular modes is inferred from travel time differences. This approach provides relatively little control of the distribution of transmitted energy among the modes and adds uncertainty to the estimation of the coupling between particular modes. An alternative approach is proposed to use an array of sources to selectively excite modes of the medium.

There are several advantages and challenges of using such an approach. First, this will improve the ability to estimate the actual coupling between different modes. Second, it is well known that propagation of and coupling between particular modes is most sensitive to environmental perturbations having particular spatial scales. Therefore, by exciting particular modes and not exciting other modes, the emitted signal can be tuned to be most sensitive to environmental fluctuations on a particular spatial scale. A major challenge in this approach is the tuning of the source array to ensure that only the desired modes are excited.

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Presented at 125th Acoustical Society of America Conference, Ottawa, Canada, May 17-21, 1993.

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The Advanced Engineering Laboratory of the Woods Hole Oceanographic Institution is a development laboratory within the Applied Ocean Physics and Engineering Department. Its function is the development of oceanographic instrumentation to enhance current research projects in other disciplines within the community. This report summarizes recent and ongoing projects performed by members of this laboratory.

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